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Developing a Migraine Attack Prediction System using Resting-state EEG

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Certificate of Authorship/ Originality

This thesis is the result of a research candidature conducted jointly with another university as part of a collaborative doctoral degree. I certify that the work in this thesis has not previously been submitted for a degree nor has it been submitted as part of requirements for a degree except as part of the collaborative doctoral degree and/or fully acknowledged within the text.

I also certify that the thesis has been written by me. Any help that I have received in my research work and the preparation of the thesis itself has been acknowledged. In addition, I certify that all information sources and literatures used are indicated in the thesis.

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Cao Zehong

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Abstract

Migraine is a common episodic neurological disorder with complex pathophysiology that is characterised by recurrent headaches during a set period, such as one month. A small group of migraine patients (13-31%) experience transient neurological symptoms (most frequently visual aura) prior to headache onset, while the majority of patients do not possess any premonitory symptoms. This study explored neurophysiological evidence of the resting-state electroencephalogram (EEG) power, coherence and entropy to support the cortical signals that relate to different migraine phases, and then used this to develop an EEG-based system for predicting migraine attacks. First, we investigated EEG devices, pre-processing and artefact removal methods, and feature extraction technologies, including power, coherence and entropy analysis. Next, we discovered the cyclic EEG dynamics of migraine on a cross-sectional basis. The results indicated that EEG power spectral and coherence were significantly increased in the pre-ictal group, relative to EEG data obtained from the inter-ictal group. Inter-ictal patients had decreased EEG power and connectivity relative to healthy controls, which were “normalised” in the pre-ictal patients. Furthermore, using longitudinal design, we utilised a wearable EEG device to estimate brain dynamics before migraine attacks. The results showed the EEG entropy of individual patients in the pre-ictal phase, resembling normal control subjects, was significantly higher than that in their inter-ictal phase in prefrontal area. That is, the entropy measures identified enhancement or “normalisation” of frontal EEG complexity in pre-ictal phase. Finally, based on these neuroscience discovery of inter- and pre-ictal EEG entropy in individuals, this study proposed a support vector machine (SVM) based system with 76% accuracy to predict migraine attacks. The prediction system characterised the EEG entropy of a single (prefrontal) area and favoured the application of brain-computer interface in migraine.

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